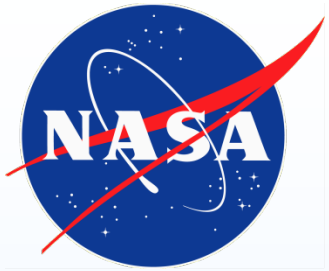

The NASA Electronic Parts and Packaging (NEPP) Program: Roadmap for FY15 and Beyond

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Acronyms

Acronym	Definition
CBRAM	Conductive Bridging Random Access Memory
CGA	Column Grid Array
CMOS	Complementary Metal Oxide Semiconductor
COTS	Commercial Off The Shelf
EEE	Electrical, Electronic, and Electromechanical
EPC	Efficient Power Conversion
FeRAM	Ferroelectric RAM
FPGA	Field Programmable Gate Array
FY	Fiscal Year
GaN	Gallium Nitride
Gen	Generation
GSFC	Goddard Space Flight Center
HEMTs	High-electron-mobility transistors
HP Labs	Hewlett-Packard Laboratories
IC	Integrated Circuit

Acronym	Definition
IR	Infrared
IR/Infineon	International Rectifier/Infineon Technologies
MOSFETS	Metal Oxide Semiconductor Field Effect Transistors
MRAM	Magnetoresistive Random Access Memory
NASA	National Aeronautics and Space Administration
NAVY Crane	Naval Surface Warfare Center, Crane, Indiana
NEPP	NASA Electronic Parts and Packaging
RERAM	Resistive Random Access Memory
SEE	Single Event Effect
SiC	Silicon Carbide
SOC	Systems on a Chip
TI	Texas Instruments
VNAND	Vertical NAND
WBG	Wide Band Gap

Technology Selection Criteria for NEPP Investigation

- **The technologies should satisfy all or most of the following criteria:**
  - **Wide applicability,**
  - **Product level or in productization, and,**
  - **No distinction: COTS to hi-reliability aerospace.**
- **Partnering arrangements with other organizations preferred.**
- **In general, we avoid:**
  - **Laboratory technologies, e.g., <TRL3,**
  - **Limited application devices with certain exceptions (critical application or NASA center specialization).**

COTS = Commercial Off The Shelf

Technology Investigation Roadmap Discussion

- **Technology assurance efforts are not explicitly included except on "Small Missions" chart.**
  - ***Guidelines are a product of many technology evaluation tasks.***
- **Only major product categories shown.**
- **Technology areas not on Roadmap but under consideration include:**
  - **Electro-optics (fiber optics),**
  - **Advanced analog and mixed-signal devices,**
  - **Imaging sensors,**
  - **Modeling and simulation,**
  - **High-speed communication (SERDES, fast data switches), and,**
  - **Adjunct processors (eg., graphics, signal processing)**
- **Note 1: Advanced CMOS technologies not explicitly included:**
  - **NEPP leverages samples from ongoing DoD and/or commercial sources.**
  - **14nm is current target.**
- **Note 2: "Reliability testing" may include product and/or package testing.**

CMOS = Complementary Metal Oxide Semiconductor

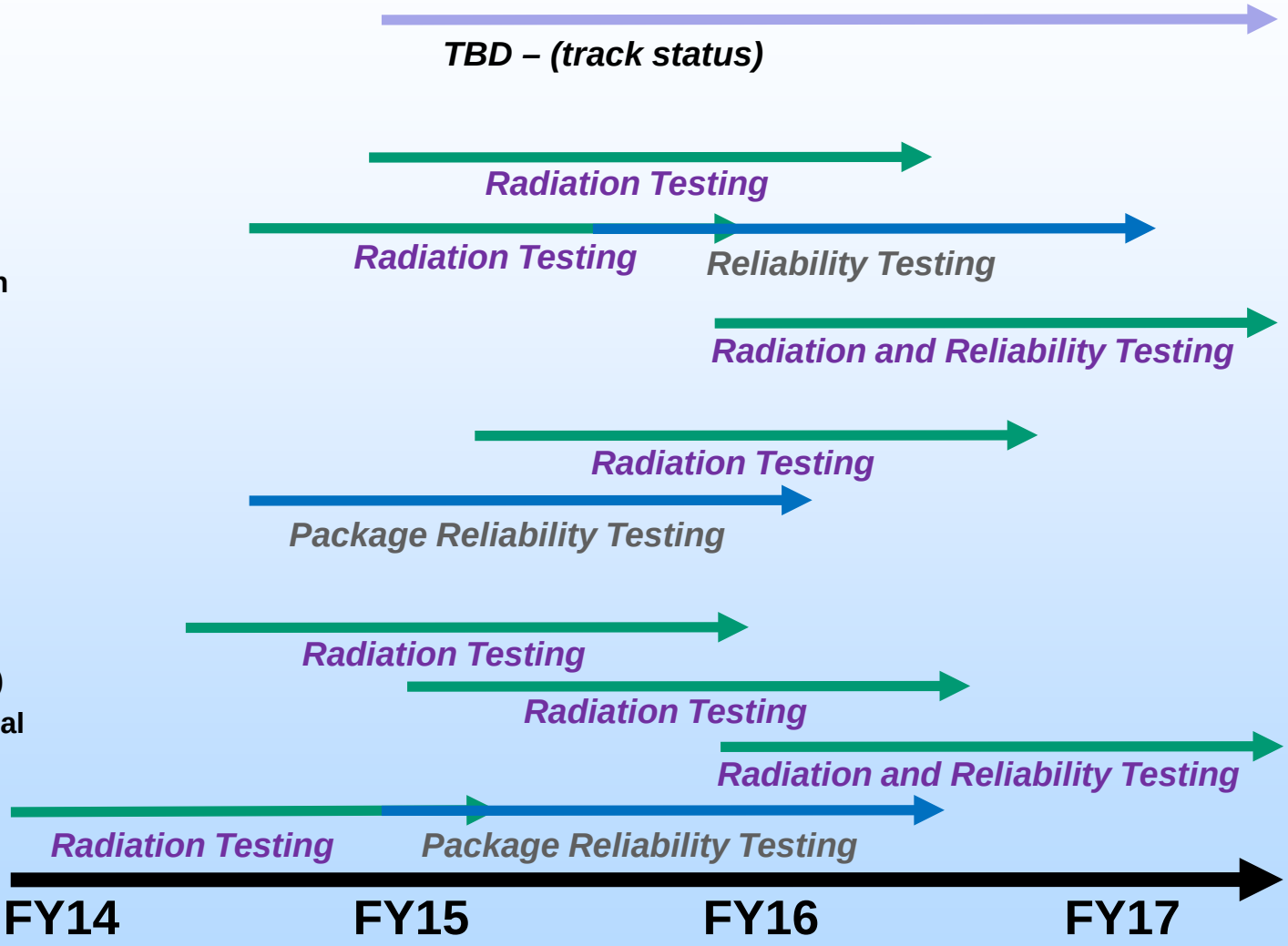
Field Programmable Gate Arrays (FPGAs)

Trusted FPGA
- DoD Development

Altera
- Stratix 5 (28nm TSMC process commercial)
- Max 10 (55nm NOR based commercial – small mission candidate)
- Stratix 10 (14nm Intel process commercial)

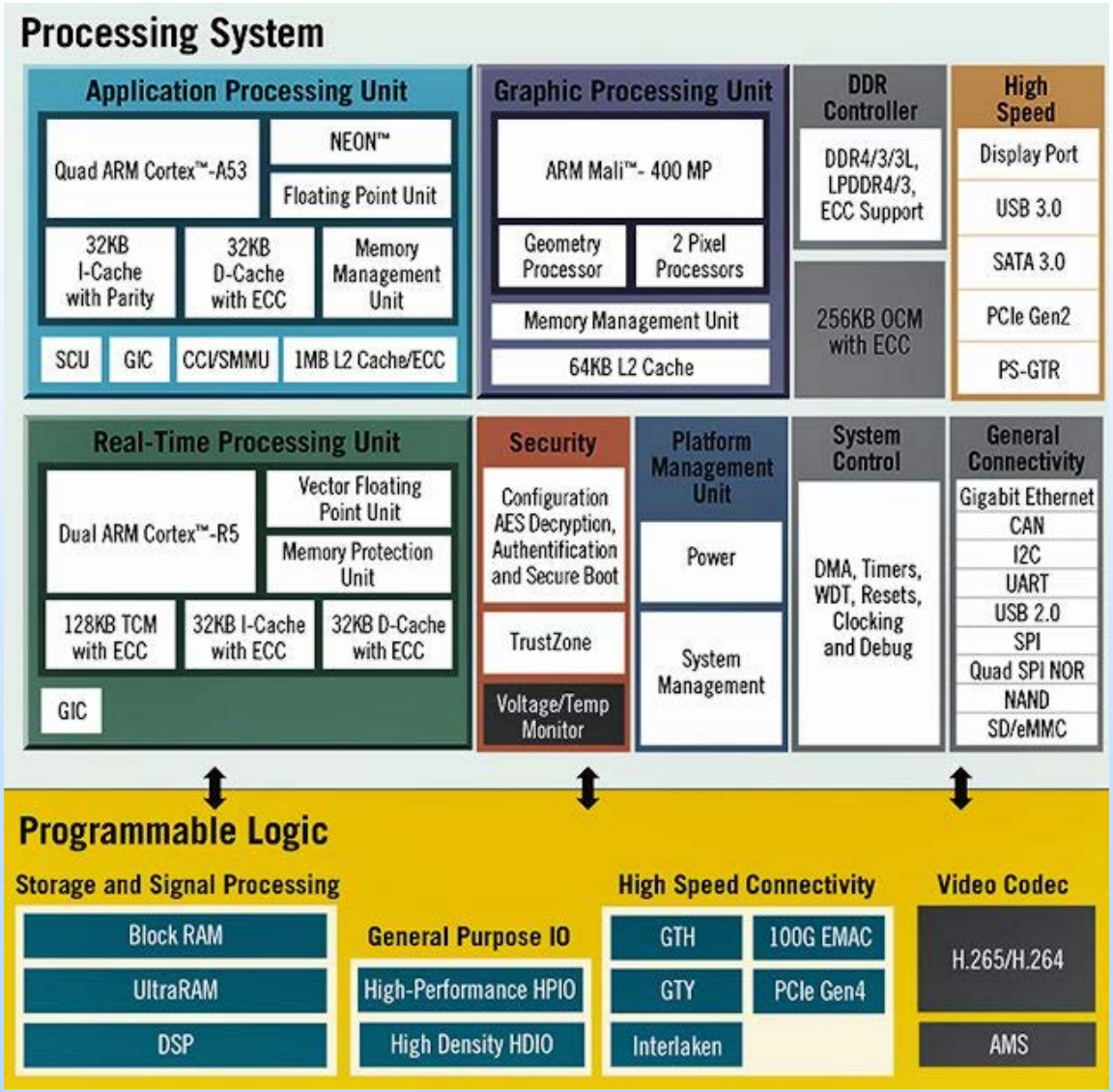
Microsemi
- RTG4 (65nm RH)

Xilinx
- 7 series (28nm commercial)
- Ultrascale (20nm commercial – planar)
- Ultrascale+ (16nm commercial - vertical)
- Virtex 5QV (65nm RH)



FY=Fiscal Year

Xilinx Zynq UltraScale+ Multi-Processor System on a Chip (MPSoC) family



From Xilinx.com

Advanced Processors

Next Generation Space Processor (NGSP)

- Joint NASA-AFRL Program for RH multi-core processor
- TBD architecture/process

RH Processor

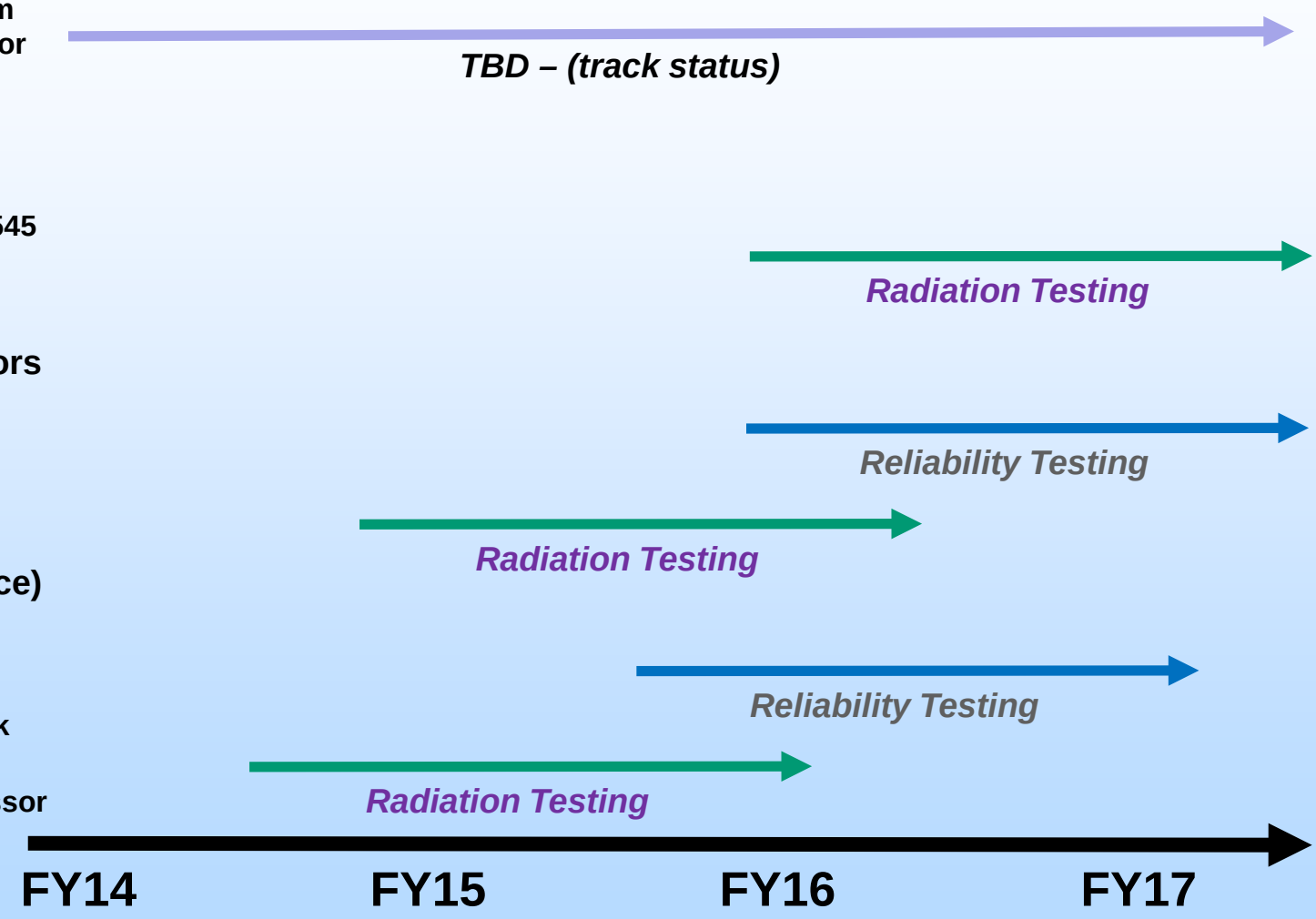
- BAE Systems RAD5510/5545
- Replacement for RAD750

Intel Broadwell Processors

- 14nm FinFET commercial
- 1st high-performance sans heatsink (lower power for performance)

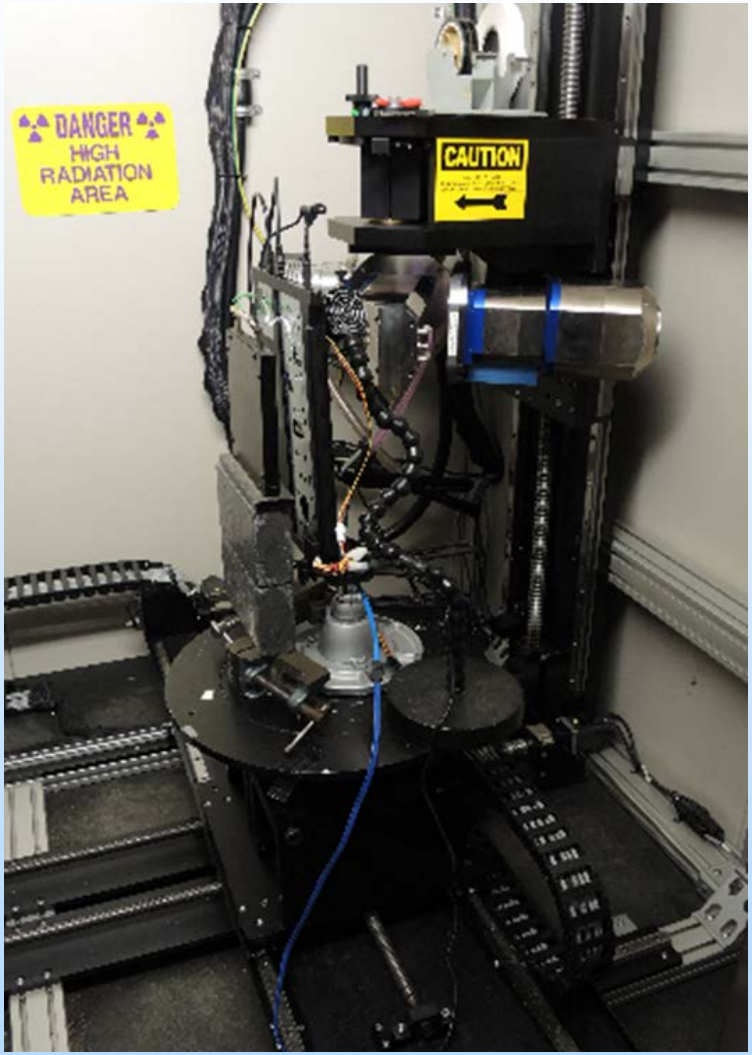
Freescale P5020/5040

- Commercial 45nm network processor
- Preparation for RH processor



Note: Future considerations under discussion include automotive "self-driving" processor options.

Preliminary Radiation testing of 14nm Intel with Navy Crane



Microcontrollers and Mobile Processors (Small Missions)

TBD – other

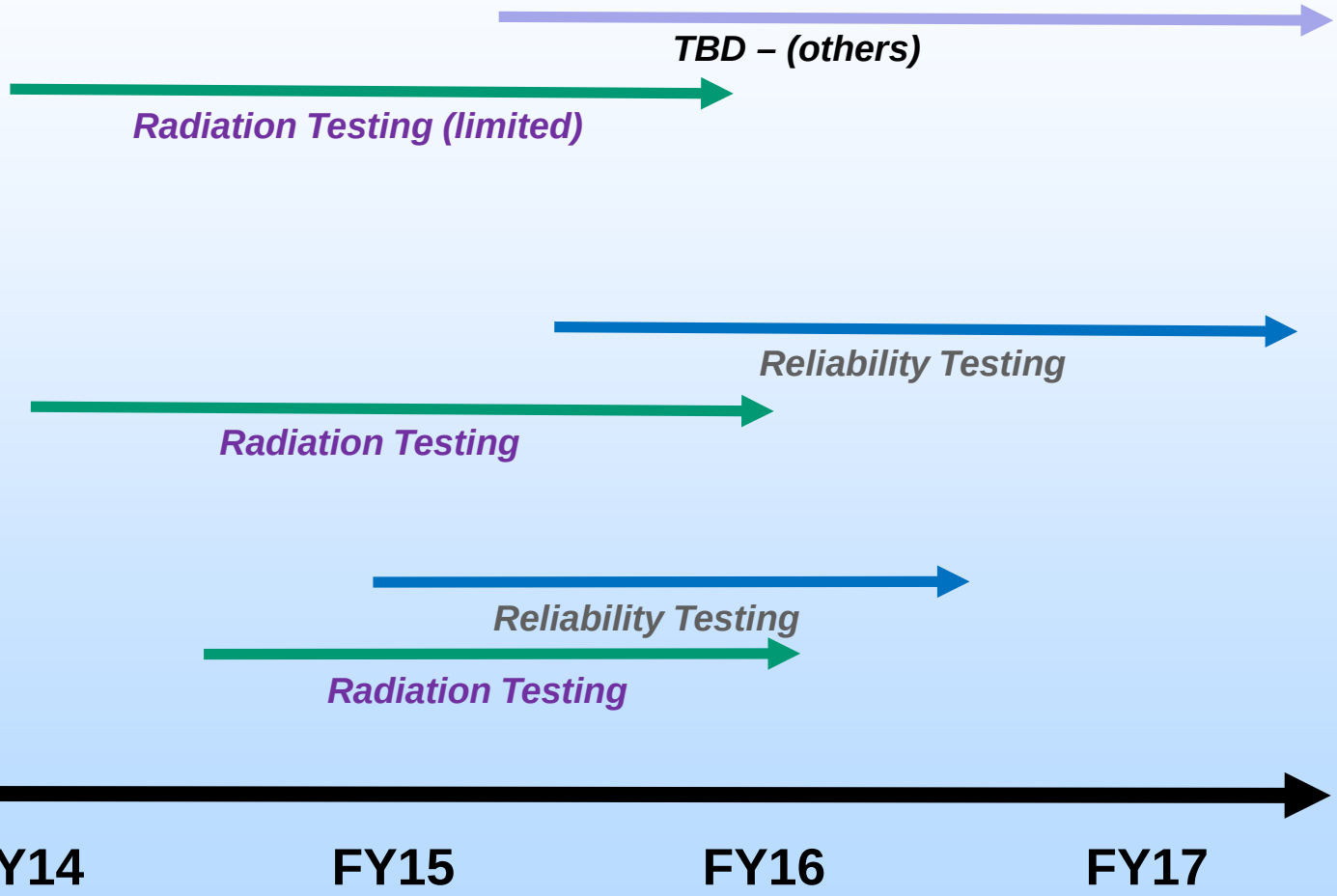
- Atmel AT91SAM9G20, and TI Sitara AM3703,
- ARM (Snapdragon), Intel Atom mobile

TI MSP430

- Popular CubeSat microcontroller
- Several varieties

Freescale MPC56XX

- 90nm on-shore fab
- Automotive Grade
- Being used for both part and board level testing



TI=Texas Instruments

Commercial Memory Technology

Other
- MRAM
- FeRAM

TBD – (track status)

Resistive
- CBRAM (Adesto)
- ReRAM (Panasonic)
- ReRAM (Tezzaron)
- TBD (HP Labs, others)

Radiation and Reliability Testing

Radiation and Reliability Testing

Radiation and Reliability Testing

TBD – (track status)

DDR 3/4
- Intelligent Memory (robust cell twinning)
- Micron 16nm DDR3
- TBD – other commercial

Radiation Testing

Radiation Testing *Reliability Testing*

TBD – (track status)

FLASH
- Samsung VNAND (gen 1 and 2)
- Micron 16nm planar
- Micron Hybrid memory Cube
- TBD - other commercial

Radiation and Reliability Testing

Radiation and Reliability Testing

Radiation and Reliability Testing

TBD – (track status)

FY14 **FY15** **FY16** **FY17**

MRAM=Magnetoresistive Random Access Memory
FeRAM=Ferroelectric RAM
CBRAM=Conductive Bridging Random Access Memory
ReRAM=Resistive Random Access Memory
HP Labs=Hewlett-Packard Laboratories
VNAND=Vertical NAND

Small Missions

EEE Parts Guidelines

- Small missions (Class D, CubeSat – 2 documents)
- System on a chip (SOC) single event effects (SEE) guideline

Guideline development

Guideline development

Commodities evaluation

- See commodities roadmaps for processors, power
- CubeSat Star Tracker

Radiation Testing

Reliability Testing

Automotive grade electronics

- Multiple classes of electronics (passives, actives, ICs)
- Testing by NASA and Navy Crane

Reliability Testing

Alternate test – board level

- Freescale MPC56XX
- Automotive Grade
- Both part and board level reliability testing

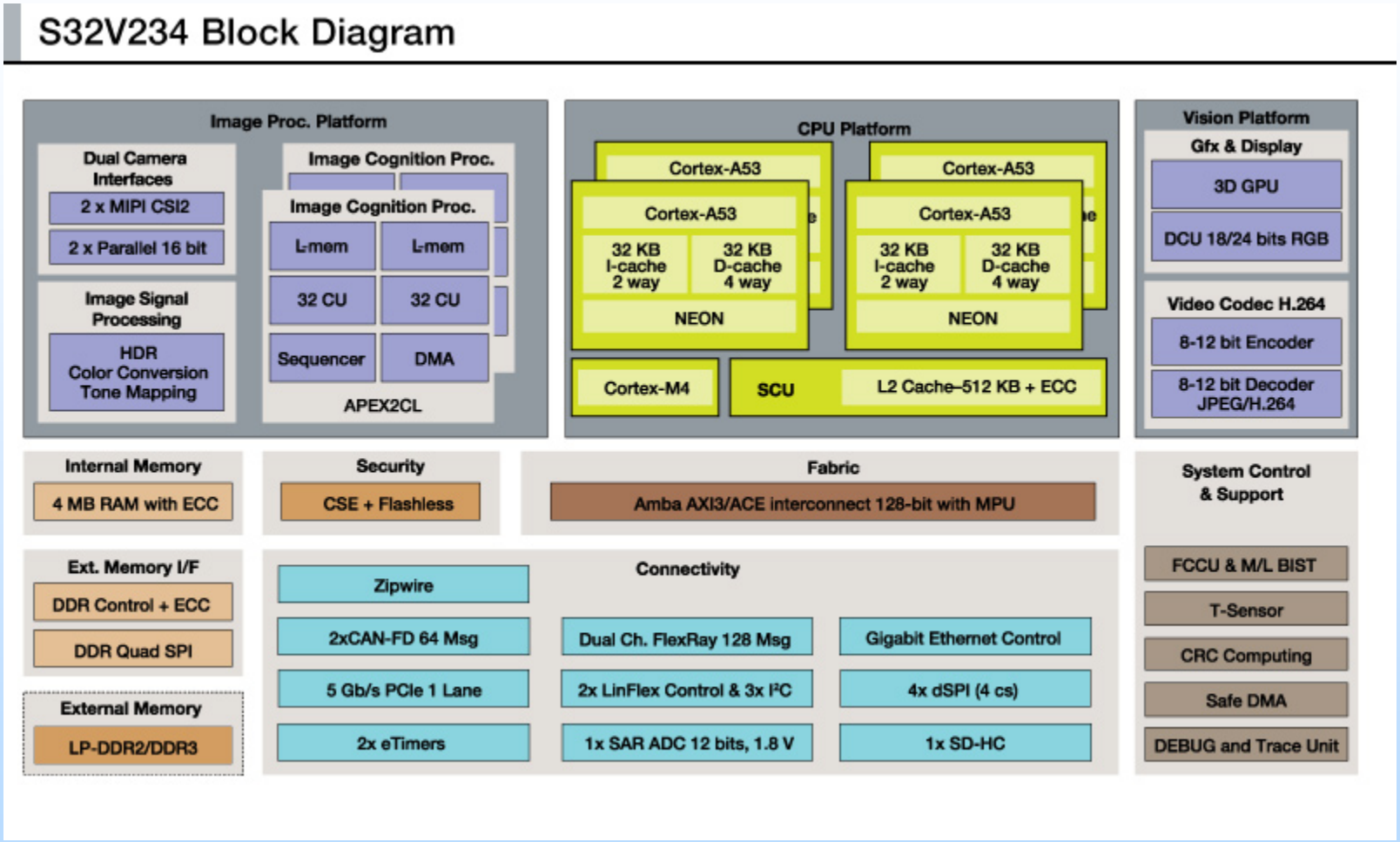
Reliability Testing

Radiation Testing

FY14 **FY15** **FY16** **FY17**

EEE = Electrical, Electronic, and Electromechanical NAVY Crane = Naval Surface Warfare Center, Crane, Indiana ICs = Integrated Circuits

Automotive Processors and Systems for Self-Driving Cars?



From Freescale.com

Wide Band Gap (WBG) Technology

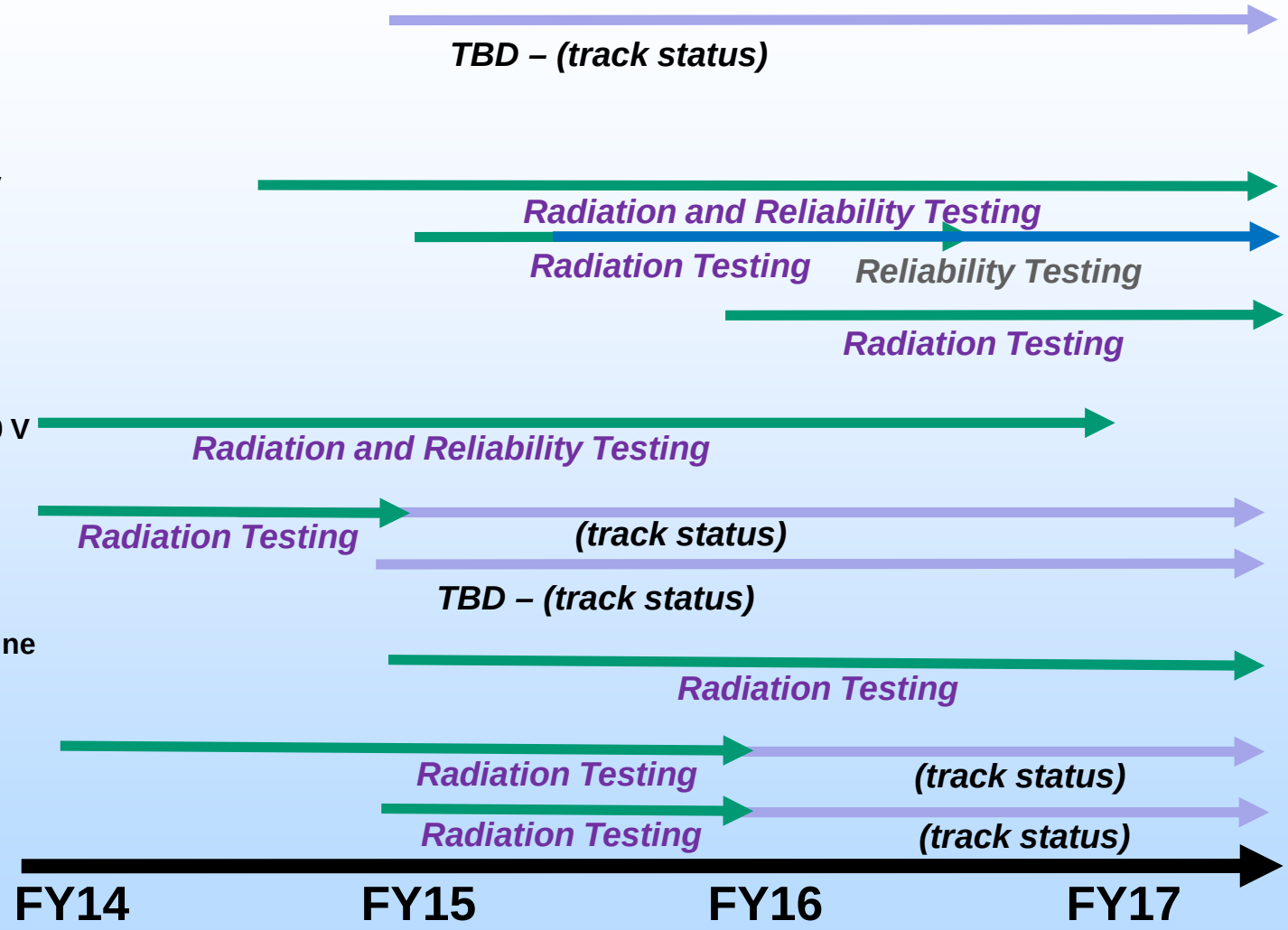
GaN Class V development
- Microsemi with EPC

GaN Enhancement Mode HEMTs
- EPC Gen 2-3, 200 V - 600 V
- GaN Systems 100 V, 650 V
- Panasonic 600 V (target)
- IR/Infineon 600 V (target)

SiC MOSFETs
- Cree Gen 1-2 1200 V - 1700 V
  Gen 3- narrower neck
- STMicro baseline SEE test
- Rohm Trench design

SiC Diodes
- Manufacturer X SEE baseline and hardening efforts

SiC ICs
- Ozark IC
- Manufacturer X



EPC=Efficient Power Conversion
GaN=Gallium Nitride
Gen=Generation
HEMTs=High-electron-mobility transistors
IC=Integrated Circuit
MOSFETS=Metal Oxide Semiconductor Field Effect Transistors
SiC=Silicon Carbide

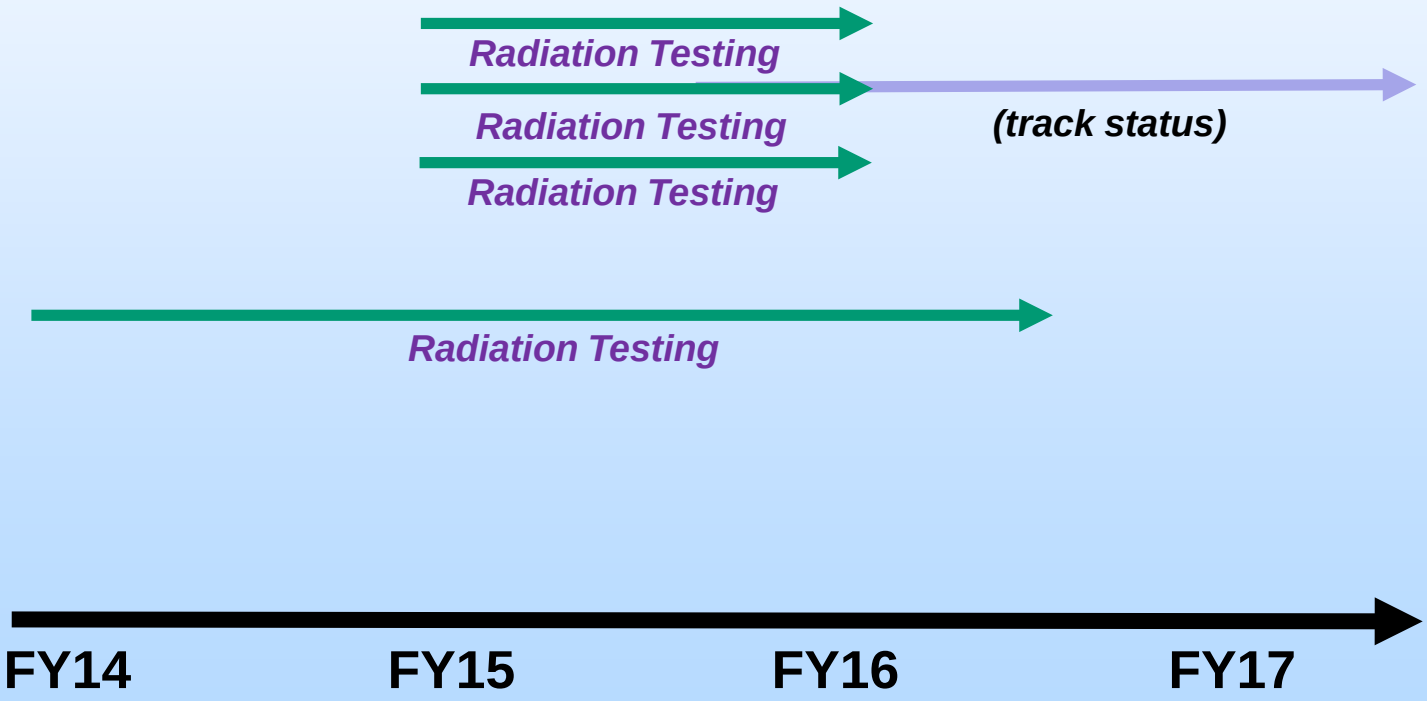
Silicon Power Devices

MOSFETs – Rad Hardened

- Microsemi i2MOS
- Infineon superjunction 100 V, 600 V (target)
- IR/Infineon R8 trench 20 V

Schottky Diodes

- Multiple vendors, reverse voltage ratings, and forward current ratings



Packaging Technologies (1 of 2)

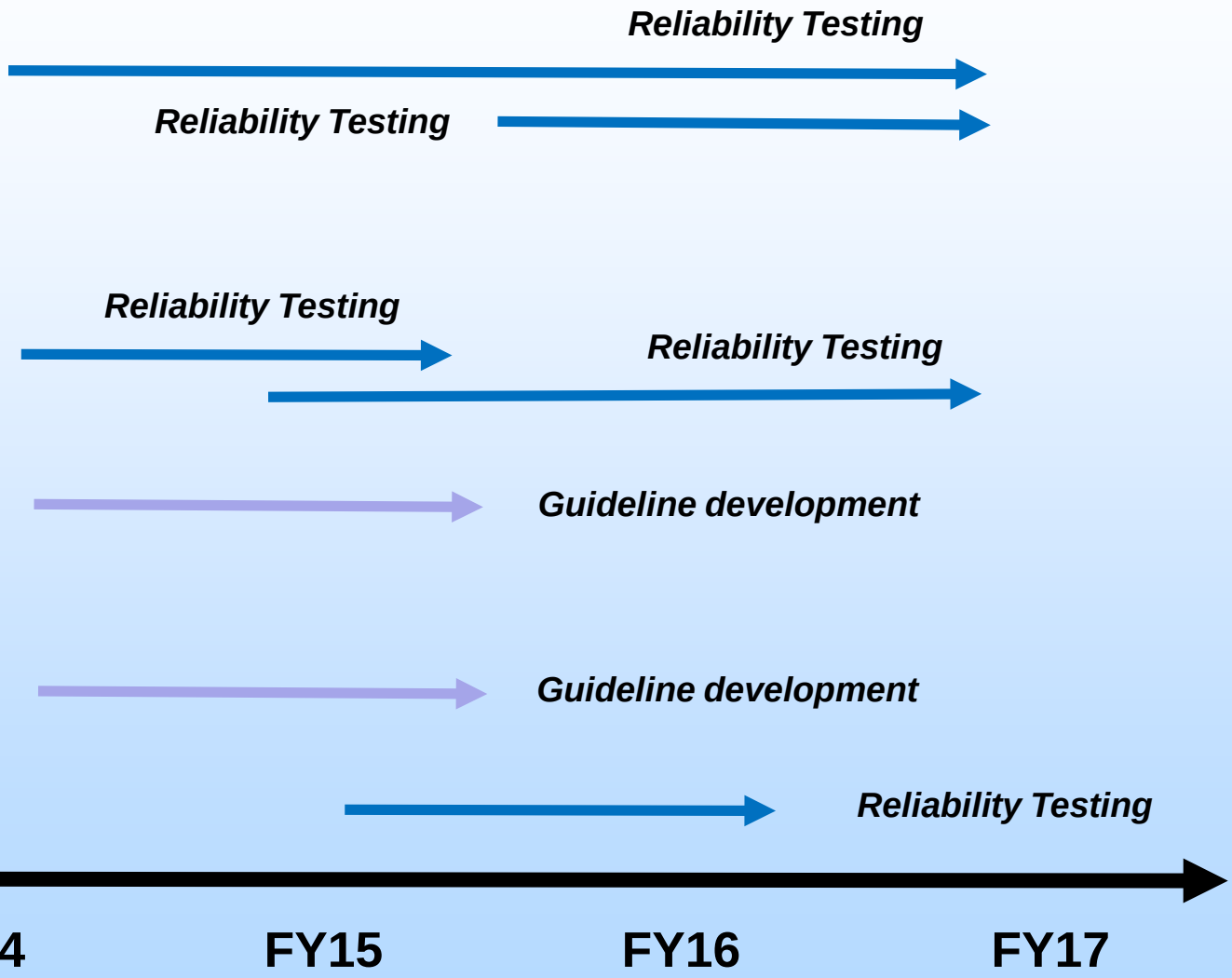
High Density, Non-hermetic Column Grid Array (CGA)
- Xilinx CN/Kyocera Daisy Chain
- Microsemi Daisy Chain
- *Materials analysis, long term stress, root cause failure*

HALT Methodology/Qualification
- HALT/HAST comparison
- Plastic BGA matrix

Area Array Column
- Selection guide

Thermal Interface Materials
- Selection guide

PBGA Thermal Cycle Evaluation



Packaging Technologies (2 of 2)

Bump Reliability
- Technology review
- Test vehicle options

Guideline research

3D Packaging Technologies
- Technology review
- Test vehicle options

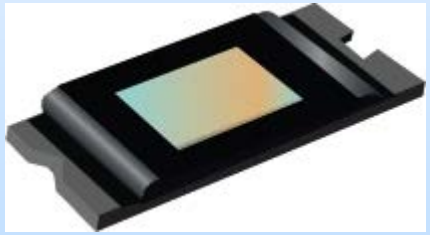
Guideline research

QFN package reliability
- Reliability/Qualification metrics

Reliability Testing

And Just When You Think Your Roadmap is Set, New Parts are Released

- **Examples**
  - **More complex processors**
    - **TI Multicore DSP+ARM KeyStone II System-on-Chip (SoC)**
  - **Integrated “instruments”**
    - **TI DLP2010NIR – near IR sensing and controller**



IR=Infrared

Summary and Comments

- **NEPP Roadmaps are constantly evolving as technology and products become available.**
  - **Like all technology roadmaps, NEPP's is limited to funding and resource availability.**
  - **Not shown are TBD passives and connector roadmaps under development.**
  - **NEPP is working to develop preliminary plans on interfacing to the NASA Reliability and Maintainability Program and its work on Model Based System Engineering (MBSE) approaches.**
- **We look forward to further opportunities to partner.**

https://nepp.nasa.gov